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Visual Recognition Training: Effectiveness of Computer Graphics

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Visual Recognition Training: Effectiveness of Computer Graphics

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The effectiveness of computer graphics in training Navy personnel to recognize and identify several types of radar jamming was investigated. Dynamic (moving) and static (nonmoving) computer graphics were developed to enhance the unique or distinguishing features of each type of actual radar jamming. A title and a one-sentence description of the jamming accompanied each of the graphics. The subjects, who were students at the Fleet Combat Training Center, Pacific, were assigned to one of five experimental groups for preview training consisting of static graphics with or without descriptions, dynamic graphics with or without descriptions, or jamming descriptions only or to a control group that received no preview training. Test results using videotapes of actual jamming indicate that dynamic graphics with descriptions are useful for visual recognition training.

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FOREWORD

This experiment was conducted in support of advanced development project Z1177 (Advanced Computer-aided Instruction), subproject Z1177-004 (Remote Site Training Using Microcomputers) and was sponsored by the Chief of Naval Operations (OP-01). The purpose of this subproject was to conduct training research to improve electronic counter-countermeasures (ECCM) training readiness in the surface fleets.

This report presents an experiment, conducted in conjunction with the subproject, that investigated the overall effectiveness of using computer graphics for teaching Navy personnel a visual recognition skill (specifically, recognizing and identifying radar jamming). The value of animation (motion) and a brief verbal description was also explored. The results are intended for the use of members of the military training community who are involved with training development, computer-based graphics, simulation, and visual recognition training.

The outstanding cooperation of personnel at the Fleet Combat Training Center, Pacific is very much appreciated.

B. E. BACON
Captain, U.S. Navy
Commanding Officer

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Technical Director

SUMMARY

Problem and Background

Interest in computer graphics has increased with the advent of computer-based instruction. However, since computer graphics increase instructional development costs significantly, we need to know whether they are necessary and, if so, how they should be used. Probably, the importance of computer graphics depends largely on the task to be learned.

This experiment was conducted in conjunction with a computer-based course teaching a visual recognition skill; that is, recognition of radar jamming. This course teaches operations specialists and fire control, electronics, and electronics warfare technicians to recognize 11 types of radar jamming. Actual jamming can be difficult to identify because the patterns are complex and their critical features ambiguous. Therefore, computer graphics were developed to enhance, clarify, and exaggerate the unique or distinguishing features of each type of jamming.

Purpose

This experiment was conducted to investigate the overall effectiveness of using computer graphics for teaching Navy personnel a visual recognition skill; specifically, recognizing and identifying radar jamming. The value of animation (motion) and a brief description was also explored.

Method

The experimental subjects received some preview instruction before they took the computer-based jamming recognition course. Their performance on the pretest for this course was compared with that of a control group that received no preview instruction.

The experimental subjects were 114 male enlisted personnel attending electronic counter-countermeasure and advanced warfare classes at the Fleet Combat Training Center, Pacific. The control group was formed from data previously collected from 93 students who had attended the computer-based course.

The experimental subjects were randomly divided into five groups according to which of the following preview conditions they received: static (nonmoving) graphics with and without descriptions, dynamic (moving) graphics with and without descriptions, and descriptions only. The students took the preview training on one day and, after a one-day delay, took the pretest of the computer-based course. Mean pretest scores, response times, and total preview times of all groups were compared.

Results and Discussion

1. The groups using the dynamic graphics (with and without descriptions) scored statistically higher on the pretest than did the other groups (including the control group, which received no preview training).

2. The differences among the mean response times of the experimental and control groups were not statistically significant.

3. The mean total time that the subject groups spent on the preview condition differed significantly among the groups. The dynamic-graphics-with-descriptions group spent more time viewing the graphics than did the other groups.

Our findings suggest that considering the prototypical features or characteristics of the visual patterns to be learned is important in developing the graphics and that the use of descriptions added to the value of the dynamic graphics.

Conclusions

Dynamic graphics that consider the characteristics of the visual patterns to be learned appear to be a useful way of giving students advance information about the visual characteristics of complex patterns. Descriptions seem to add to the value of dynamic graphics.

Recommendation

Training developers should consider using dynamic computer graphics that focus on the unique or distinguishing features of visual patterns to be learned to give students advance information of visual characterisitcs of complex patterns.

CONTENTS

INTRODUCTION

Problem and Purpose

The use of graphics to enhance the learning process has interested the educational community for years. Research has shown that the use of graphics and text illustrations can (1) improve learning by helping students understand what they have read, substituting pictures for words, and enhancing student enjoyment and (2) increase retention of information by encoding information in more than one way (i.e., pictures plus words) and by repetition (Levie & Lentz, 1982).

The advent of computer-based training has increased the interest in using computer graphics for instruction since computer graphics can be made to move and flash as well as be presented in color. However, the evidence on how much computer graphics contribute to the success of the instruction remains mixed. Since computer graphics significantly increase instructional development costs, we need to know whether they are necessary and, if so, how they should be used (Moore, Nawrocki, & Simutis, 1979). It is likely that the importance of graphics depends largely on the task to be learned. For example, the computer graphics used in this study were a logical extension of the instruction since the skill to be taught was a visual recognition skill. The skill was recognition of radar jamming. The graphics consisted of a series of simplified visual patterns designed to organize the learning of important visual characteristics. Dynamic (moving) graphics as well as static (nonmoving) graphics were developed. Descriptions were another feature. Therefore, this experiment explored the overall effectiveness of using computer graphics in training as well as the value of animation and descriptions.

Background

The present experiment investigates the influence of computer graphics on the recognition of visual patterns by Navy personnel. A critical skill in certain Navy ratings is to be able to recognize various types of electronic countermeasures (ECMs)--also known as radar "jamming"--that may obscure targets being tracked on a radar scope. Recognizing jamming requires differentiating among the visual characteristics of several jamming types. The Navy Personnel Research and Development Center developed a successful computer-based training program that teaches Navy personnel to recognize 11 different types of jamming (McDonald & Crawford, 1983, 1986). This program combines videotapes of jamming with computer-based instruction and graphics that enhance the visual characteristics of the types of jamming.

The computer-based instruction for recognition of jamming focuses on categorical features of the different types of jamming. Unique critical visual features define and identify each type of jamming. However, actual jamming can be very difficult to identify because the patterns are complex and their critical features can be ambiguous. For training, these features are difficult to display in real-life videotape presentations. As a result, the videotapes by themselves were not sufficient to train students to identify each type of jamming and graphics were used to highlight the critical features. These graphics were "cartoon-like" pictures that clarify, enhance, and exaggerate the unique features of each jamming type, much as political cartoonists exaggerate unique facial features of various politicians.

The literature on concept learning provides evidence that teaching students to recognize a prototypical concept requires lots of examples and emphasis on the prototypical features (Gagne & Briggs, 1979). The computer graphics provided examples of these

prototypical features. This experiment tested the use of computer graphics to enhance the critical distinguishing features of the types of jamming and asked the following three questions:

1. Are computer graphics effective in teaching students to recognize different types of jamming?

2. Are dynamic graphics more effective than static graphics?

3. Do short verbal descriptions of the jamming types enhance the value of the graphics?

METHOD

The experiment was conducted in conjunction with a course which taught jamming recognition. To avoid the confounding influence of the jamming recognition instruction, the experiment was conducted before the instruction for the visual recognition training course started. The pretest for the course, which presented the subjects with videotapes of actual jamming to identify, served as the dependent variable. The experimental subjects were randomly divided into five groups based on which of five preview conditions were used. The five preview conditions consisted of static computer graphics with and without descriptions, dynamic computer graphics with and without descriptions, and descriptions only. The performance of the subjects in these five groups on the pretest to the visual recognition training course was compared to that of a control group that did not receive any preview instruction.

Subjects

The experimental subjects were 114 male enlisted personnel attending electronic counter-counter-measure (ECCM) and advanced warfare classes at Fleet Combat Training Center, Pacific (FCTCPAC). Their Navy ratings included operations specialists (OSs), fire control technicians (FTs), electronics technicians (ETs), and electronics warfare technicians (EWs) and their rates ranged from E-3 to E-7 (Table 1).

A control group of 93 subjects was formed from data previously collected for students who had attended the same computer-based course, but who had not received the preview instruction.

Experimental Materials

The experimental subjects viewed static and dynamic computer graphics for 11 types of jamming in the following five preview conditions:

1. Static graphics with descriptions. Two computer frames each presented a static graphic representation of each jamming type with a title for the jamming and a brief verbal description (approximately one sentence) of the jamming below the graphic.

2. Dynamic graphics with descriptions. Two computer frames each presented dynamic graphic representation of each jamming type with a description and title below the graphic. The same titles and descriptions were used as in condition 1.

3. Static graphics without descriptions. The same static graphics were used as in condition 1 with only the jamming title below each graphic (no description).

Table 1

Distribution of Subjects by Rating, Rate, and Preview Graphics Group

Rating[a] and Rates of Subjects	Number of Subjects					
	Experimental Group[b]					Control[c] Group
	1	2	3	4	5	
OSSA	1	1	0	1	1	5
OSSN	3	2	5	2	3	18
OS3	3	3	4	3	3	28
OS2	11	4	5	5	8	19
OS1	6	7	11	13	3	17
OSC	0	1	0	0	0	3
FTM3	0	2	0	0	0	0
ETN2	0	0	0	1	0	0
ETR3	0	0	0	0	1	0
EW2	0	0	0	0	1	0
EWC	0	0	0	0	0	1
FTGSN	0	0	0	0	0	1
FTGCM	0	0	0	0	0	1
Total	24	20	25	25	20	93

[a]OS = operations sepcialist
FTM = fire control technician (surface missile)
ET = electronics technician
EW = electronics warfare technician
FTG = FT (gun fire control)

[b]The experimental groups had the following preview conditions:

Group 1. Static graphics with descriptions.
Group 2. Dynamic graphics with descriptions.
Group 3. Static graphics without descriptions.
Group 4. Dynamic graphics without descriptions.
Group 5. Descriptions only.

[c]Control group received no preview graphics instructions.

4. Dynamic graphics without descriptions. The same dynamic graphics were used as in condition 2 with only the jamming title (no description) below each graphic.

5. Descriptions only. Only the jamming title and description were presented for each type of jamming.

Dependent Measures

The dependent measures in the experiment were the students' scores on the pretest of the computer-based ECM recognition training course. The pretest consisted of identifying two videotaped examples of 11 types of actual jamming (22 items). In addition, the computer measured subjects' response time (in seconds) to recognize each example of jamming and the total time (in minutes) that each experimental subject spent in the preview condition.

Experimental Procedure

Data were collected from May 1983 to June 1984. The preview conditions preceded the regular computer-based ECM recognition training of ECM and advanced warfare classes at FCTCPAC. Each of these classes was scheduled to be taught once a month or every two months and had 8 to 10 students. Students from each class were assigned randomly to one of the five experimental groups. The students took the preview condition on one day. After a one-day delay, students in all groups took the pretest and proceeded to the computer-based training (which is discussed in McDonald & Crawford, 1986).

Equipment

The equipment[1] used for this training included a TERAK microcomputer (an LSI-11 based, dual floppy disk drive system with a 56K byte memory), a keyboard, and a CRT display for the presentation of black and white graphics and text. The computer was used for presentation of instruction graphics, test, and test results, and for data collection. A Betamax videotape player presented the videotapes of the jamming on a TV monitor.

RESULTS

Table 1 presents the enlisted rates and ratings of the subjects. An analysis revealed no differences in the enlisted rates between the experimental and control groups.

Figure 1 shows the mean pretest scores of the experimental and control groups. (The mean scores with standard deviations are listed in the appendix.) An analysis of variance revealed statistically significant differences between the pretest scores of groups 1 through 4 and those of groups 5 and 6 ($F(1,205) = 1.55$, $p < .001$). Further analysis revealed that the groups using the dynamic graphics (groups 2 and 4) had statistically higher scores on the pretest than did the groups using the static graphics (groups 1 and 3) ($F(1,92) = 6.17$, $p < .01$). Finally, according to subsequent tests for differences, the dynamic-graphics-with-descriptions group (2) accounted for the significant differences. An analysis of variance between the scores of the groups with descriptions and those of the groups without descriptions showed no significant differences ($F(1,92) = 2.82$, $p < .09$).

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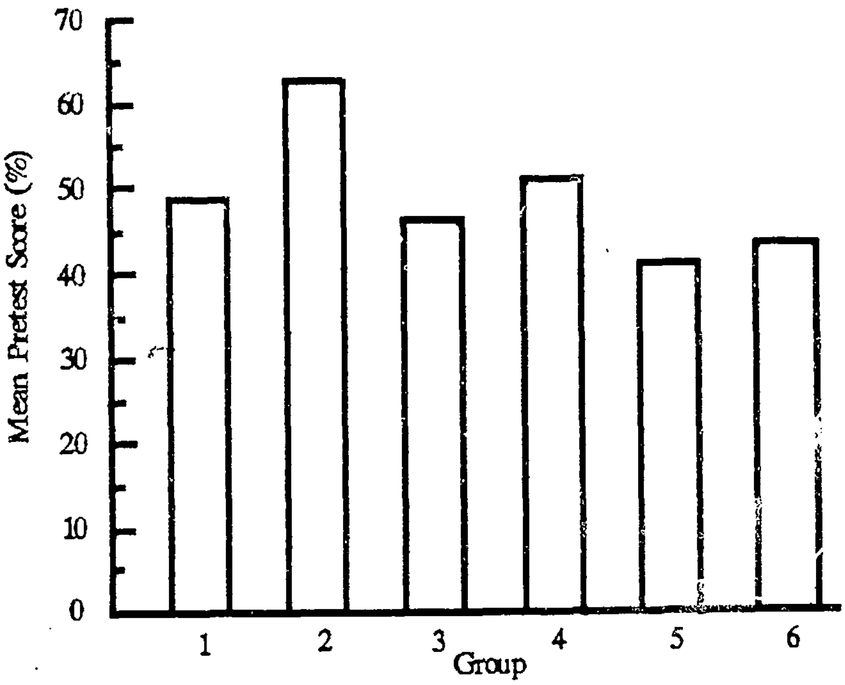
[1]Identification of the equipment is for documentation only and does not imply any endorsement.



1. Static graphics with descriptions
2. Dynamic graphics with descriptions
3. Static graphics without descriptions
4. Dynamic graphics without descriptions
5. Descriptions only
6. No preview instruction (control)

Figure 1. Mean pretest scores for all groups.

The computer measured and recorded the response time in seconds from the moment the jamming segment was presented in the pretest until the student responded. Figure 2 shows the mean response times of all groups. (The mean response times with standard deviations are listed in the appendix.) The response times of the groups did not differ significantly ($F(5,201) = 1.00$, $p < 0.419$). It is interesting to note, however, that the descriptions-only and control groups (5, 6), which did not preview the graphics displays, had the longest response times.

Figure 3 shows the mean total time (in minutes) that the subjects spent actually previewing the graphics. (The mean total times with standard deviations are listed in the appendix.) An analysis of variance revealed significant differences between experimental groups ($F(4,109) = 18.09$, $p < .000$). A subsequent test for differences revealed that the dynamic-graphics-with-descriptions group (2) spent more time viewing the graphics prior to taking the pretest than did the other groups.

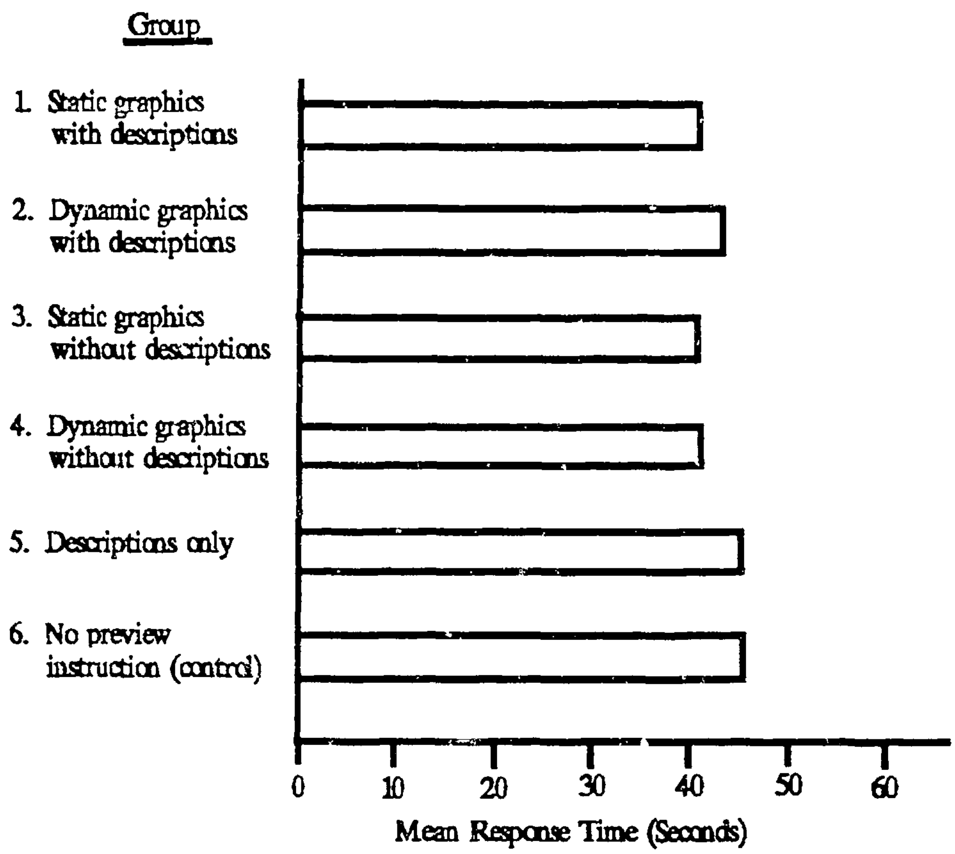


Figure 2. Mean response times for all groups.

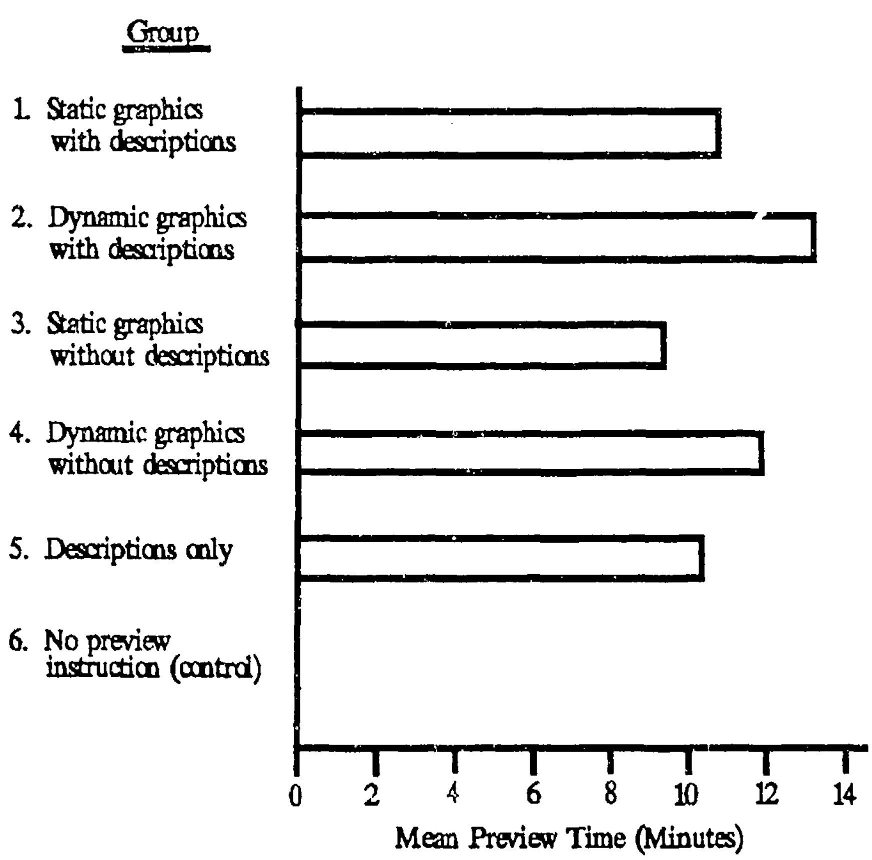


Figure 3. Mean total preview times for all groups.

DISCUSSION

This experiment examined the overall effectiveness of graphics, the value of movement, and the use of descriptions with the graphics in teaching students the skill of jamming recognition. The results revealed that graphics were helpful and also provided specific information about the use of movement and descriptions.

The graphics groups (1-4) scored higher than the descriptions-only and control groups (5, 6) on the pretest for the computer-based ECM recognition training course. Therefore, the graphics provided these subjects with enough information to recognize actual instances of jamming even though they had not seen actual jamming before.

A more detailed look at the results showed that the dynamic-graphics-with-descriptions group accounted for the significant differences, which suggests the importance of both movement and descriptions. This finding must be interpreted with caution because of the similarity between the dynamic graphics and pretest. Both are moving pictures. Descriptions appeared to add to the value of the dynamic graphics although there were no main effects for the descriptions. The descriptions may have provided the dynamic-graphics group with a more efficient way to process and retain the preview information.

Analysis of the time spent previewing the graphics provides another clue as to the reason for the superior performance of the dynamic-graphics-with-descriptions group. This group of subjects spent more time previewing the graphics than did the other graphics groups. Possibly, this was because the combination of dynamic graphics with descriptions gave them more information to process. The differences between the groups in actual pretest response time were not statistically significant, however.

The results of this experiment provide some interesting guidelines for the use of computer graphics in visual recognition training. First, computer graphics appear to be a useful way of giving students advance information about visual characteristics of complex patterns. The findings of this study suggest that it is important to consider the prototypical features or characteristics of the visual pattern to be learned in developing the graphics. In our case, simplifying the visual pattern was important. However, including the movement turned out to be critical even though it did add some complexity. Finally, the findings suggest that the use of descriptions added to the value of the dynamic graphics.

CONCLUSIONS

Dynamic graphics that consider the characteristics of the visual patterns to be learned appear to be a useful way of giving students advance information about the visual characteristics of complex patterns. Descriptions seem to add to the value of dynamic graphics.

RECOMMENDATION

Training developers should consider using dynamic computer graphics that focus on the unique or distinguishing features of visual patterns to be learned to give students advance information of visual characterisitcs of complex patterns.

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APPENDIX

MEAN PRETEST SCORES, RESPONSE TIMES, AND TOTAL PREVIEW TIMES WITH STANDARD DEVIATIONS FOR EXPERIMENTAL AND CONTROL GROUPS

Appendix

Mean Pretest Scores, Response Times, and
Total Preview Times with Standard Deviations

Group	N	Results Mean	SD
Mean Pretest Scores (%)			
Experimental groups			
1. Static graphics with descriptions	24	48.41	21.69
2. Dynamic graphics with descriptions	20	62.50	14.46
3. Static graphics without descriptions	25	46.24	15.59
4. Dynamic graphics without descriptions	25	51.16	15.15
5. Descriptions only	20	40.95	19.58
Control groups			
6. No preview instruction	93	43.47	17.89
Mean Response Times (seconds)			
Experimental groups			
1. Static graphics with descriptions	24	40.83	14.87
2. Dynamic graphics with descriptions	20	43.90	15.03
3. Static graphics without descriptions	25	40.68	15.23
4. Dynamic graphics without descriptions	25	41.32	12.74
5. Descriptions only	20	45.30	10.40
Control groups			
6. No preview instruction	93	45.88	15.28
Mean Total Preview Times (minutes)			
Experimental groups			
1. Static graphics with descriptions	24	10.66	1.46
2. Dynamic graphics with descriptions	20	13.10	1.44
3. Static graphics without descriptions	25	9.72	1.20
4. Dynamic graphics without descriptions	25	11.92	1.28
5. Descriptions only	20	10.45	1.95
Control groups			
6. No preview instruction	93	--	--

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